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(54) **Pharmaceutical preparation for the treatment of inflammatory processes**

(57) A pharmaceutical preparation is described while is useful for the treatment of inflammatory processes being accompanied by an increased distribution of cytokines and/or tissue factor in the human body, which preparation contains Antithrombin III as active ingredient.

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## Description

[0001] The present invention relates to a pharmaceutical preparation for the treatment of inflammatory processes.

[0002] Sepsis is one of the main causes of death in developed countries and is commonly associated with the consumptive coagulopathy disorder, disseminated intravascular coagulation (DIC). One of the most common causes of sepsis is gram-negative or gram-positive bacterial infection. Lipopolysaccharide (LPS) or endotoxin, a cell wall component of gram negative bacteria such as *Neisseria meningitidis*, causes the production of proinflammatory, pyrogenic cytokines such as tumor necrosis factor  $\alpha$  (TNF $\alpha$ ), interleukin-1 (IL-1), interleukin-6 (IL-6) and interleukin-8 (IL-8). The circulatory levels of IL-6 and IL-8 have been shown to positively correlate with the severity of disease. These proinflammatory cytokines induce the expression of procoagulant tissue factor on monocytes and endothelial cells, thereby activating the extrinsic coagulation pathway. LPS can also activate factor XII, the contact phase of the intrinsic coagulation pathway. Activation of the coagulation cascade frequently leads to DIC, which is characterised by a pronounced depletion of coagulation factors and inhibitors. The consequence of this decrease in coagulation inhibitors, such as Antithrombin III (AT III), is uncontrolled thrombin formation leading to fibrin deposition in the microvascular beds; the reduction in clotting factors and platelets results in bleeding diathesis. Simultaneously, the fibrinolytic system is activated increasing the likelihood of haemorrhage. Patients with congenital or acquired AT III deficiency and neonates/young children who have immature vascular endothelial anticoagulant systems, and therefore low levels of the coagulation inhibitors such as Protein C, are much more susceptible to DIC in the course of septic shock. Hence down-regulation of proinflammatory cytokine would be a desirable treatment for sepsis induced DIC.

[0003] During DIC, there is a massive consumption of AT III, the major plasma coagulation inhibitor. This is confirmed by a common observation in patients with septic shock where the plasma AT III levels in non-survivors are significantly lower than in survivors, and this decrease is more marked in individuals with DIC associated with sepsis. The general consensus is that an AT III level of less than 60% of normal results in a 100% mortality rate. Apart from its inhibitory action on thrombin AT III also has potent inhibitory effects on other coagulation serine proteases including factors IXa, Xa, XIa and XIIa. The rationale for treatment of DIC patients with AT III concentrate is therefore to replace the consumed inhibitor, so that thrombin formation could be controlled.

[0004] The present invention relates to the anti-inflammatory properties of AT III concentrates which are distinct from its anti-thrombin and anti-clotting capability.

In a series of experiments the mechanism by which AT III inhibits LPS induced coagulation related inflammatory events i.e. the expression of procoagulant tissue factor and cytokines has been investigated. Human whole blood, isolated mononuclear cells (MNCs) or human umbilical vascular endothelial cells (HUVECs), when stimulated with *E.coli* LPS, responded with a dose dependent increase in the secretion of IL-6 and cell surface expression of tissue factor. AT III dose dependently inhibited these responses to LPS. Two surprising aspects arise from this data. Firstly, AT III is a potent inhibitor of thrombin, factor Xa and other activated clotting factors, but it is not known to inhibit tissue factor activity or expression. Secondly, AT III, a serine protease, is not known to interact with the cytokine network, yet IL-6 production evoked by LPS in the presence of AT III was decreased. Therefore AT III is not acting purely as an anti-coagulant but may also affect the signalling mechanism for regulation of the proinflammatory cytokines.

[0005] Subject of the invention is therefore the use of Antithrombin III for the manufacture of an anti-inflammatory pharmaceutical preparation. Such a pharmaceutical preparation inhibits the production of proinflammatory cytokines and of tissue factor and is useful for the treatment of a sepsis induced disseminated intravascular coagulation (DIC), especially if caused by lipopolysaccharides (LPS).

[0006] Another subject of invention is the use of AT III for the prophylaxis and treatment of vasculitis like the systemic-necrotizing type as the polyarteritis nodosa or the Churg-Strauss syndrome (allergic angitis). Furthermore AT III can be used to prevent/treat hypersensitive vasculitis, whether caused by external stimuli like the Schoenlein-Henoch purpura, serum sickness or infectious vasculitis. Vasculitis induced by endogenous antigens during/after cancer or systemic diseases of the connective tissue are included as well as the immune-vasculitis like the Wegener's granulomatosis, Kawasaki disease, systemic lupus erythematosus, Behcet syndrome, thrombangiitis obliterans, arteritis temporalis etc. Other autoimmune diseases like the rheumatoid arthritis are accompanied by inflammatory reactions, which are characterized for instance by the release of inflammatory cytokines like IL-6.

[0007] The following describes the anti-inflammatory properties of AT III.

[0008] Human umbilical vein endothelial cells or purified MNCs were stimulated with 0-10ng/mg of LPS (*E.Coli* 2nd International Standard for Endotoxin) for 4-6 hours, in the absence or presence of AT III. The cells were then spun and the supernatants were used for cytokine measurement, while the cells were washed and assayed for tissue factor activity. IL-6 and IL-8 were measured by specific ELISA while tissue factor production was determined by tissue factor specific functional chromogenic assay. Table 1, 2 and 3 show typical results observed in the three cellular systems. With

increasing doses of AT III, 20-40 IU/ml in these experiments, there was a corresponding decrease in the production of TF, IL-6 and IL-8.

Table 1

%inhibition of TF, IL-6 and IL-8 production by AT III, in the presence of 1 ng/ml of LPS, in MNCs.			
	% Inhibition		
AT III (IU/ml)	20	30	40
TF	18,1	36,6	58,1
IL-6	49,0	72,5	89,2
IL-8	-19,4*	-7,6*	8,8

\* - denotes potentiation

[0009] In isolated MNC systems, AT III inhibited the production of both tissue factor and IL-6 in a dose dependent manner. At 20 and 30 IU/ml, AT III potentiated the expression of IL-8, but a reduction of 8,8% was observed at 40 IU/ml.

Table 2

%inhibition of TF, IL-6 and IL-8 production by AT III, in the presence of 1 ng/mg of LPS, in HUVEC.			
	% Inhibition		
AT III (IU/ml)	20	30	40
TF	7,3	14,3	36,3
IL-6	18,5	32,7	69,0
IL-8	-18,1*	4,3	21,3

\* - denotes potentiation

[0010] As found with MNC, AT III also inhibited expression of tissue factor, IL-6 and IL-8 by LPS stimulated HUVEC.

Table 3

%inhibition of TF and IL-8 production by AT III, in the presence of 10ng/mg of LPS, in whole blood.			
	% Inhibition		
AT III (IU/ml)	20	30	40
TF	54,42	88,14	92,54
IL-6	100	100	100

\* - denotes potentiation

[0011] As the above results illustrate, in whole blood, AT III inhibited the production of tissue factor and

IL-6 to a greater extent when compared to MNCs or HUVECs; with ~ 93% inhibition of TF at 40 IU/ml AT III.

[0012] These results indicate that, apart from the inhibition of thrombin and other activated clotting factors, AT III may have a role in modulating the levels of proinflammatory cytokines. Hence, AT III concentrates could be used clinically to down-regulate the expression and production of pro-inflammatory cytokines (TNF $\alpha$ , IL-1, IL-6, IL-8) and procoagulant tissue factor, induced by bacterial LPS, as in the case of sepsis induced DIC.

[0013] Based on the above mentioned findings a pharmaceutical preparation containing AT III has been developed for the treatment of inflammatory processes which are characterized by an increased distribution of cytokines and/or tissue factor in the human body. Such preparation may be administered by injection or infusion. Normally it will be offered for sale as a dry substance in a vial with a pierceable cap together with a separately packed solvent. The amount of the active ingredient for each administration is normally between 250 and 2500 IU. As a solvent water pro injection, Ringer lactate solution or an isotonic water solution may be used which may contain citrate, glucose, sodium hydrogenphosphat, one or several amino acids, human albumin or an infusion solution containing a plasma replacement.

#### Claims

1. Use of Antithrombin III (AT III) for the manufacture of a pharmaceutical for the treatment or prevention of vasculitis or rheumatoid arthritis.
2. Use of AT III according to claim 1 characterized in that polyarteritis nodosa, allergic angitis or hypersensitive vasculitis is treated or prevented.
3. Use of AT III according to claim 1 characterized in that Wegener's granulomatosis, Kawasaki disease, systemic lupus erythematoses, Behcet syndrome, thrombangiitis obliterans or arteritis temporalis is prevented or treated.
4. Use of AT III according to claim 1 characterized in that rheumatoid arthritis is prevented or treated.